Racal Mobilcal Ltd.
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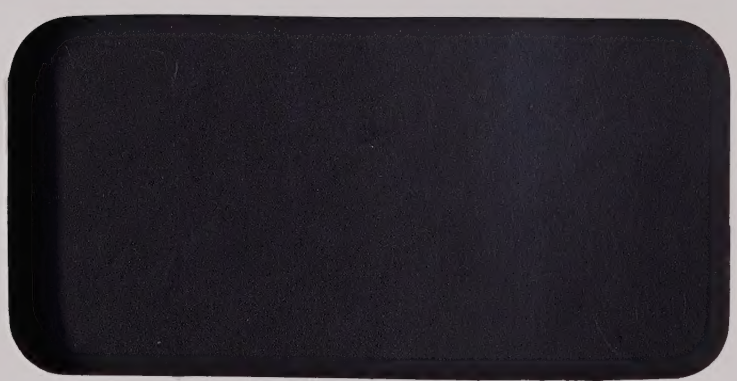
# L.F. SIGNAL GENERATOR
# J3

## Instruction Manual
**(for Serial Numbers after 351)**

ADVANCE



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# Introduction



The Advance J3 Signal Generator is an LF instrument incorporating a high output level from a balanced, floating 600 Ω output. The main output, which is metered, gives 15V into 600Ω (30V EMF). The frequency range of 10Hz to 100kHz is provided on four decade ranges, and the 6: 1 reduction drive with capacitor tuning gives high resolution of frequency with minimum bounce.

Three additional outputs are available, a 1W low impedance output, a square wave output and a low distortion output. The solid state circuitry results in low heat dissipation, giving a high order of frequency stability and reliability.

Switched step attenuators give 60dB of attenuation and the variable level control can be used to provide a further 20dB of attenuation with negligible hum and noise on the output.

## FREQUENCY

Range: 10Hz to 100kHz in 4 decade ranges.
Scale: Common 320° circular scale for all ranges, including nominal 5% frequency overlap at both ends.
Setability: To 1 part in $10^4$
Accuracy: 2% of reading ± 1HZ
Typically 1% ± 1HZ.

## OUTPUTS

1) MAIN OUTPUT
30V r.m.s., e.m.f. (15-0-15V) from balanced floating output of impedance 300-0-300 Ohms (15V r.m.s. into 600 Ω load).

Output Impedance tolerance: 5% – Balance 3%
Balanced Attenuator: 20dB and 40dB (60dB total).

Accuracy: 0.3dB and 0.5dB respectively, each half.
Fine level control, from 0 to full output (Common to Outputs 1,2 and 3).

2) LOW IMPEDANCE OUTPUT
3V r.m.s., e.m.f. from approximately 1 Ohm.
With Output 1 fully loaded, Output 2 will deliver a ~~minimum~~ Typically of 1 Watt into 5 Ohms.

3) LOW DISTORTION OUTPUT (at rear of instrument).
Typically 2.5V r.m.s. from approximately 5kΩ. Overall flatness 0.3 dB.

4) SQUARE WAVE, 0 to +5V, independently controlled. Source Impedance approximately 1kΩ. Rise and Fall times better than 1μs into less than 100pF. Mark-space ratio better than 1.1:1.

all o/p levels are flat within 1db over the full frequency range

Below 50Hz the maximum o/p level is not available on load, on O/P's 1&2 (Typically 20V at 10Hz)

## OUTPUT LEVEL METER

Scaled 0-30V r.m.s. Open Circuit for Output 1. Scale also common to Output 2.
Decibel scale, referred to +20dBm into 600 Ω
The meter accuracy is 3% of F.S.D.

## DISTORTION

1) Outputs 1 &2: less than 0.1% above 100Hz rising to less than 0.5% at 10Hz.

Typically better than 0.05% from 200 Hz to 100kHz

2) Low Distortion Output: Typically better than 0.02% above 200Hz rising to 0.2% at 10Hz.

## PROTECTION

All outputs rated for full load simultaneously
All outputs Short-Circuit proof. Visible indication of overload on Output Level Meter (Intermittent reading).

## SUPPLY VOLTAGE

105V – 117V – 210V – 223V – 234V. ± 10%
40–400Hz, approximately 20VA.
Also 40 – 48V. DC/300mA Max.

## OPERATING TEMPERATURE RANGE:

0°–50°. Full specification over range 15°–35°C

## DIMENSIONS

27 x 27 x 13 cms (10.7 x 10.7 x 7.2 in.)

## WEIGHT

6kg (13 lbs.)

### 3.1 SWITCHING ON

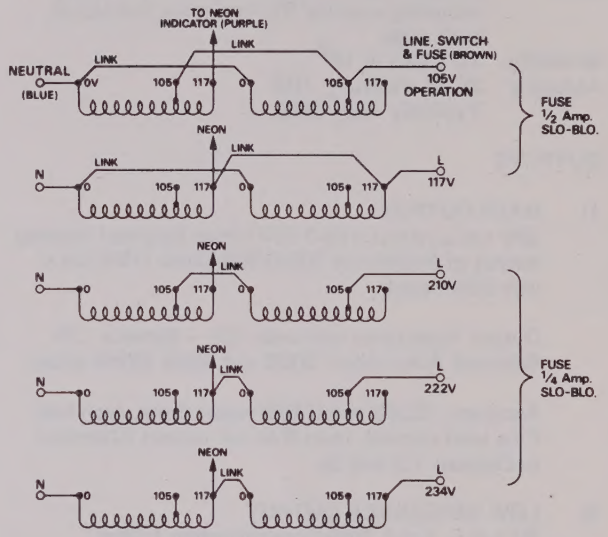
(i) Make sure that the voltage supply tap on the transformer is set correctly, and that the correct fuse is used. The transformer is accessible upon removal of the top cover of the instrument. (see 5.1). Unless labelled otherwise, the J3 is delivered for 234V ± 10% (See Fig. 1 for transformer taps, links and fuse ratings).

(ii) Set the support/carrying handle to the required operating position. The handle is released by pulling both fixing bushes outwards, and it can then be turned to lock in any one of three positions.

(iii) It is advisable to turn the Output Level Fine control to minimum before switch-on, to avoid large surge outputs for the few seconds that the oscillator takes to stabilise.

(iv) The Instrument is ready for use half a minute after switching on and fully 'settled' within five minutes. No special precautions with cooling need to be taken normally but natural ventilation should not be restricted when operating at high ambient temperatures.

Fig. 1 Power Supply Tappings, links, and Fuse ratings




### 3.2 BLOCK DIAGRAM

The broad outlines of the instrument are shown in the block Diagram in Fig. 2. Power is supplied by a Regulated supply which includes the protection circuits. The low distortion output from the Wien bridge oscillator of variable frequency is taken through a front panel Fine Output Level control to the Power Amplifier, which drives the transformer-coupled power outputs and the Meter circuitry. The same oscillator drives a Squarer, the level being adjustable through a second front panel control.

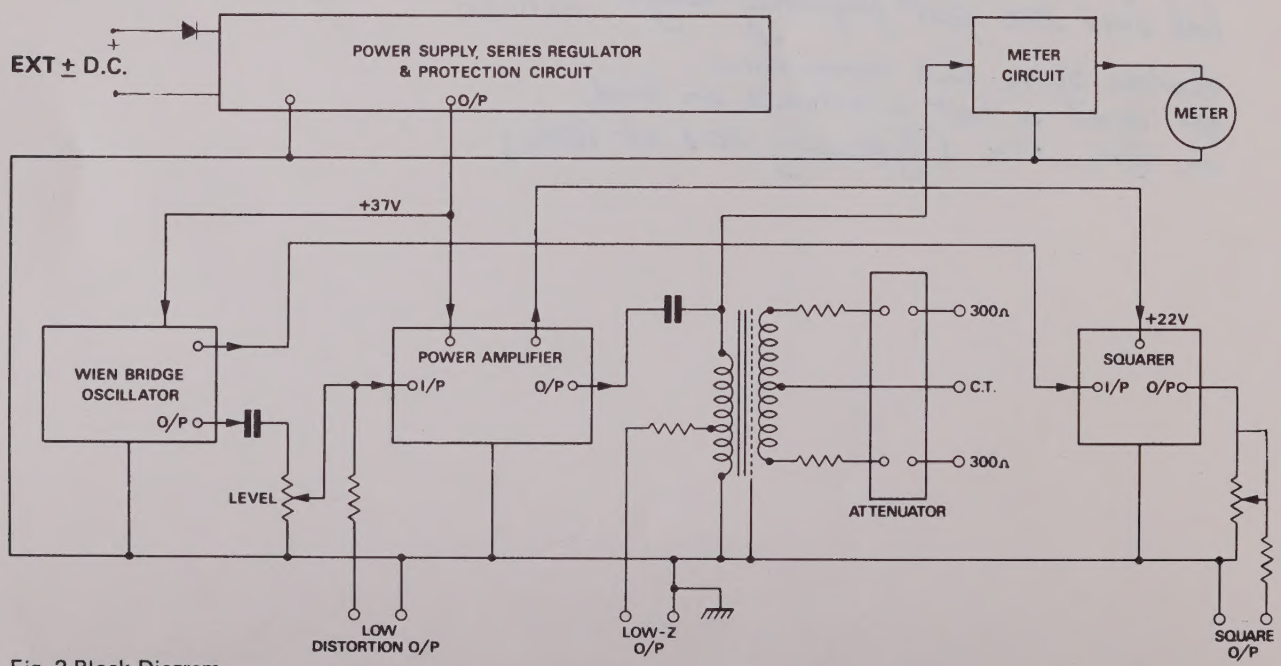



Fig. 2 Block Diagram

### 3.3 SELECTION OF FREQUENCY

To set frequency, the Range Switch is turned to the appropriate range. The fine control of Frequency is a circular dial which is set at the desired part of the decade in use. Although the accuracy claimed on the dial calibration is typically 1%, the resolution of the gang capacitor in the oscillator is essentially infinite and frequency can be set to any required value to within 1: $10^4$. It is often convenient to use the independent square wave output to monitor the exact frequency by a Timer Counter.

### 3.4 BALANCED OUTPUT 150-0-15V r.m.s., e.m.s.,

(i) Output 1 is mainly intended for making balanced 600 Ω line measurements. In such use the diresired amplitude is set on the Meter ÷ remembering that half the Open Circuit voltage will appear across the load — and the balanced attenuators are used to give ÷ 10 or ÷ 100 facilities.

(ii) The balanced output can be used *unbalanced,* terminated in 600 Ω, in which case Metering and the use of the attenuators is exactly as above. If a low level unbalanced signal from a 600 Ω source is required from the J3 — i.e. less than -40dB — it is advisable to use half the balanced output with the centre tap at the low impedance end, and use a 300 Ω resistor in series externally to make up to 600 Ω . This avoids the pickup of small spurious signals due to the unbalance of the output, which can be significant at high attenuation.

(iii) *Half* the balanced output can also be used. If terminated with 300Ω, again the Metering and use of attenuators remain unchanged, but of course only half the output voltage is being used, i.e. the output is a quarter of the e.m.f. indicated.

(iv) In addition, the balanced output can be used in any of the above ways without matched termination, i.e. operated into any load between open and short circuit It would then behave like an e.m.f. with a source impedance of 600 or 300 Ω , depending on whether the whole or half the output is used. The attenuators remain operative.

(v) Finally, there is no reason why different loads should not be used on each half output, rememebering that they will be in phase opposition, and the resultants either measured or calculated.

(vi) The e.m.f. from the bifilar transformer secondaries is essentially balanced. The output resistances at the terminals are balanced to within 3%. Each attenuator may introduce unbalance of 3% in e.m.f., but the unbalance of output impedance remains unchanged, at a maximum of 3%.

*Warning:*

1. The maximum voltage applied between the balanced output and ground must not exceed 500V d.c. or peak a.c.

2. The passage of *direct current* through the balanced output must be restricted to less than 50mA, to prevent damage to the output resistors. A much smaller current than this, however, can saturate the output transformers and severely increase distortion. If some d.c. must be passed, it is an advantage to use the attenuators which will effectively reduce the current reaching the transformer by the same ratio. The permissible d.c. is a function of frequency and acceptable distortion, and can best be found by experiment.

### 3.5 LOW-Z OUTPUT 3V r.m.s., e.m.f. $Z_0 \triangleq 1$ Ohm

(i) This can be used unloaded, and the e.m.f. can be read as 1/10th the Meter reading. The response is flat and the distortion less than at the Balanced Output. The full range of amplitude, i.e. 3V r.m.s., e.m.f., is available when output 2 is loaded by 5 Ω or more, simultaneously with normal loading of output 1.

If output 1 is unloaded and unattenuated, the load on output 2 can be reduced to 3 Ω at full output.

Loads smaller than 3 Ω may cause the protection circuit to operate, unless level is reduced. Under near short circuit conditions the maximum current available from output 2 is approximately 0.9A r.m.s.

Note: When the protection circuit operates because of excessive loading, the output level automatically 'cycles on and off' at intervals of about 1 second. This is indicated by a corresponding swing on the output Meter.

### 3.6 LOW DISTORTION OUTPUT 2.5V r.m.s., e.m.f. $Z_0 \triangleq 5$k Ohm

(i) This output, directly from the oscillator, is taken from the slider of the Fine Level Potentiometer through a buffer resistor. It can be loaded without detriment to the performance of the other outputs, although a change of loading reflects on the output levels.

(ii) An external signal from another Generator can be injected into this output and be resistively mixed with the low distortion J3 signal. The mixed signal is then available at amplified outputs 1 and 2 to permit intermodulation measurements on amplifiers, etc. However, leads left attached to this output can pick up and inject unwanted signals and noise into the J3.

Individual peak current limiting has been applied to both output transistors TR105 and TR106. For the latter, diode D105 joins the output to the junction of diodes D103 and D104, and thus limits peak -ve load current in TR106 to approximately 0.6 A., i.e. the drop in 1 Ohm resistor R122 at the diode potential.

Positive peak current limiting is effected by inserting a 1 Ohm sampling resistor in the collector of TR105, to energise the base of TR107 and to clamp the feedback loop through R126 to the base of TR103. R125 serves to protect against excessive base current in TR107.

### 4.3 POWER OUTPUTS

The output of the Power Amplifier is coupled through C116 and a section of the Frequency Switch of the J3, to the primary of T1 or T2. These are the Low Frequency and High Frequency output Transformers and operate respectively from 10Hz – 10kHz and 10kHz – 100kHz. Their feedback and secondary winding are also switched by the Frequency Switch as range is changed.

(i) LOW -Z OUTPUT

A tapping on the primary of each output transformer provides 3V r.m.s., e.m.f., between ground and the Low -Z terminal. The source impedance is approximately 1Ω permitting over 1 Watt to be delivered into a load of 5 Ohms. The maximum available *current* is approximately 0.9A r.m.s.

(ii) 300-0-300 Ohm OUTPUT

Bifilar wound secondaries on each transformer supply 2 x 15V r.m.s., e.m.f. to the balanced output terminals through balanced attenuators of 20 and 40dB. Separate resistors are brought in by the Frequency Switch to pad the secondaries of both transformers to 300 Ohms each. The respective centre-taps are also switched and the outputs are thoroughly screened .

(iii) A protection circuit will cause the J3 to 'Cycle' on-off this condition being visible on the output meter if an attempt is made to draw excess power from the instrument. In view of its low output resistance excess power is almost invariably drawn from the Low-Z output by a short circuit. The protection circuit will be explained in the section dealing with the Power Supply. (See reference to peak current limiting).

### 4.4 SQUARE WAVE OUTPUT

As has already been mentioned, a tap on the load resistor of the output of the Wien Bridge Oscillator supplies the input signal to the Squarer. Emitter follower, TR131, further isolates the Oscillator from the Squarer to minimise interaction. The output from TR131 is coupled through C132 to the base of TR132, which, with TR133 forms a Schmitt trigger circuit in which the long-tail current through R134 is switched on-off at the collector of TR133. The output level is controlled by potentiometer, R142, and taken to the output terminal via R139. C133 is a speed-up capacitor to the base of TR133 and preset trimpot, R136, sets the mark-space ratio. R143 is selected on test in parallel with R142 to adjust the output level to be between +5V and +5.5V.

The Squarer is supplied through buffer emitter-follower, TR134, and Zener base reference, D131, to isolate the fast transients from other parts of the J.3. The same Zener D131 after filtering serves as the reference for the Power Supply.

### 4.5 POWER SUPPLY

Long-tailed pair, TR161 and TR162, compare the Zener reference to a fraction of the d.c. output voltage at the slider of trimpot, R162. The collector of TR161 conventionally drives compounded series output emitter followers, TR164 and TR165, the latter being the main series regulator connected to a heat sink. R167 and C165 form a supply filter and d.c. load to TR161, whereas R168 is the 'a.c.' load. R169 and C164 are frequency roll-off stability components. The input to the P.S. is provided by the secondary of mains transformer, T3, and Bridge Rectifier, BR161, feeding Reservoir capacitor, C166, whose negative terminal is taken to the 0-volt (ground) line through 1 Ohm, R170.

The protection circuit referred to under Section 4.3 (iii) is composed of R164, a 2.2 Ohm resistor between TR165 and the P.S. output; transistor, TR163; R170; trimpot, R165, and C163. TR163 is connected so that its base-emitter monitors the d.c. voltage drop in R164, its collector being in common with that of control transistor, TR161. Hence, if a current of more than approximately 250mA is taken through R164, TR163 will conduct and reduce the base current available to the series control transistor. This conventional current sensing and limiting alone, would also limit the positive current peaks of the output waveform, especially at the lower frequencies.

While the current overload sensor, TR163, is arranged so that its base is d.c. biased by potential across R164, the a.c. component is balanced out in trimpot, R165, with a fraction of the opposing Singal Voltage generated across R170 and a.c. coupled via C163. In addition, the time constants are such that when the supply limits on overload, the Wien bridge oscillator is stopped and waits until its control thermistor cools before it can restart. The absence of signal effectively removes the overload from the P.S. which then restores output. The cycle of events continues until the overload is removed or the signal level is turned down. Overload is shown by the Output Level meter cycling on-off at approximately 1 second intervals. A faster 'cycling' visible on the Output Level meter generally indicates an internal fault, rather than excessive internal loading.

Note: Under certain conditions of overload, the peak current limiting circuitry of the output stage can initiate the 'cycling' of the protection circuit. This situation is most likely to arise when excessive magnetising current is required by the output transformer, either because of external d.c. magnetisation or through a fault. This initiation of cycling will cause no damage to the instrument.

### 4.6 METER CIRCUIT

Equal signals from the output of the P.A. and the feedback winding, supply the germanium diode full wave bridge rectifier through equal resistors, R151 and R152. The resultant d.c. is then set and filtered by R153, R154 and C151. The rectifier is essentially average current, as most of the applied voltage is dropped across the two equal resistors.

By monitoring the two points that supply the feedback to the Power Amplifier, the meter circuit is effectively connected to the 'ideal' transformer driving the balanced Outputs, and thus compensates for transformer losses.

### 4.7 MAINS INPUT

Transformer, T3, is conventionally arranged with a series-parallel primary and has a single well-screened secondary. The primary is switched and fused, and a Neon indicator is fed from one half primary. (See 3.1 (i) and Fig. 2)

### 4.8 EXTERNAL D.C. SUPPLY

Two coded sockets at the back of the instrument permit operation from a **FLOATING** D.C. supply of 40-48V. Current at maximum output and loading is approx. 250mA.

### 5.1 REMOVAL OF COVERS

*Warning:* Take care not to touch the supply transformer or fuse with the supply *ON*.

Each cover is held in position by four latch fasteners. Each fastener is relased by turning it so that the slot lies along the width of the instrument. It will generally be found more convenient to carry out adjustments or repairs with the instrument bottom upwards.

### 5.2 REMOVAL OF OSCILLATOR BOX COVER

This is held on by seven screws, 4 at the bottom and 3 at the top, all 7 screws working in slots. After undoing each screw by about 3 turns, the cover can be slid out. Refitting is a reversal of the above procedure, being careful to butt the cover well against the steel oscillator box when tightening the screws.

### 5.3 REMOVAL OF PRINTED CIRCUIT BOARD ASSEMBLIES

(i) Removal of Oscillator P.C.B. (Fig. 4)
This is released by undoing 4 screws, as shown in the figure. Then the yellow lead on the underside of the board to pin 'C' (Guard) is unsoldered. The board is now free and can be eased out and swivelled about the cables and leads going to the Range Switch.

(ii) Release of Master P.C.B.
- (a) Remove 4 screws securing rear panel. Disconnect the 2 leads from the Low Distortion terminals.
- (b) Undo the two screws that hold the board to the bracket near the Mains transformer.
- (c) Disconnect the two brackets that support the board to the case (top and bottom) towards the middle of the P.C.B.
- (d) Remove the top screw securing the output transistors' heat sink to the side member, near the two large electrolytics mounted on the board. Slacken the corresponding bottom screw securing the heat sink. The board can now be swivelled against the cables and harness to remove damaged components, although *many of these are accessible simply by removing the rear panel.*

Note: Complete removal of the P.C.B.'s requires disconnection of all leads, which should be clearly labelled for correct reconnection.

### 5.4 SETTING UP OF WIEN BRIDGE OSCILLATOR

(i) Work which is possible with cover removed.
The cover should not be removed unless a fault exists in the oscillator board.

1. Turn Fine Output Control to minimum.
2. Disconnect coax. lead from Point D (to squarer)
3. Check incoming +37V rail at check position on switch, or on master P.C.B. (red leads). If faulty, disconnect the oscillator from +37V rail and use an external +37V supply rated at 50mA to supply the oscillator.
4. Connect an a.c. coupled oscilloscope (1V/div., 0.1 mS/div.) to 'Oscil. Test Point' as shown in Fig. 4 (On the middle switch wafer outside the oscillator box).
5. Set frequency to approximately 3kHz, and switch on.
6. If there is no fault, oscillations should build up die out, restart and stabilise.
7. Connect D.V.M. or 20k Ω V Voltmeter, 15-50V range, across C25. Trim R22 for a reading of 13-13.5V. Examine the waveform on the oscilloscope for possible clipping, etc. It should be clean.
8. Trim R34 for 8v p-p on the oscilloscope. Restore wiring to normal.

(ii) Work with cover in position:
(In the absence of a fault, begin setting up here)
Step 7 above may be carried out by connecting a d.c. Voltmeter to 'Oscil. Test Point').

1. Connect the a.c. high impedance Voltmeter to 'Oscil. Test Point' replacing the oscilloscope. The Voltmeter should be calibrated to 1% at 2.8V r.m.s., and have a flat frequency response from 10Hz to 100kHz, inclusive of the screened cable connector.
2. Connect the Frequency counter to the Squarer output. Set this to a convenient level.
3. Select the 1-10kHz Range, and set the dial to 1kHz. Note the frequency on the counter.
4. Trim R34 for 2.8V r.m.s. on the Voltmeter and tune towards the high frequency end of scale, carefully observing the voltmeter reading. If the Wien bridge is trimmed correctly, the reading should stay constant at 2.8V.
5. Set the dial to 10kHz and trim C2 and C3 to obtain *ten times* the frequency noted in step 3 above. Note that *increasing* C2 and/or C3, *decreases* the frequency, and that *increasing* C2 and *decreasing* C3, can keep the frequency constant while *decreasing* the output of the oscillator. The two trimmers should be set for the right frequency and *least* amplitude variation over the range. Note the amplitude at 10kHz.
6. Reset 1kHz on the counter. Slacken the two grub screws that hold the tuning gang spindle in the epicyclic drive and reposition the scale to agree with the counter.
7. Set the dial to 10kHz and trim frequency to agree, with amplitude retained at that giving least variation over the band. (Step 5.)
8. Check frequency/dial agreement on 100-1000Hz and 10-100kHz ranges at various points, and if necessary, reset the dial (repeating Steps 6 and 7) for minimum frequency error overall. If the error approaches 2% a fault in the appropriate range resistors should be suspected.
9. Check 10-100Hz range, allowing for the +1Hz tolerance in the specification. The oscillator should now be set and be flat within 0.3dB.
10. Finally, return to the 1-10kHz Range at 9kHz setting, note frequency reading and 'rock' the tuning knob whilst adjusting C2 and C3 for minimum amplitude bounce. Check that the noted frequency reading has been held unaltered.
It should be noted that clockwise dial rotation producing amplitude *increase* requires *increase* (frequency lowering) of the Trimmer C3 nearest the edge of the oscillator box (grounded trimmer).
Conversely, C2 has the opposite effect.

Note: A piece of insulated wire is wrapped around the highest range resistor R8 shunting it by approx. 1/4pF This raises the frequency at the top end of the highest range by 1% approx., to produce closer agreement with the scale.

### 5.5 SETTING UP OF POWER SUPPLY

Note: All trim potentiometers on Master P.C.B. can be adjusted from the back of the board through suitable holes.

1. Turn the level control to zero.
2. Adjust R162 for +37V ± 0.5V at pin +'37V' carrying red lead.
3. Provisionally set R165 at its mid setting. *After* adjusting the Power Amplifier, the frequency is set to 3kHz and an a.c. coupled and *floating* oscilloscope is connected between +37V point and the slider of R165, to test point. The P.A. should be loaded with approximately 5 Ohms at the Low -Z tap, the 40dB attenuator engaged to load the balanced output, and the Level control should then be advanced and R165 adjusted, for minimum signal on the oscilloscope while increasing level to maximum. The adjustment is eased if the oscilloscope Timebase is set to 1μ s/div. and 'free run', in which case the 3kHz signal appear as a multiple trace whose width should be reduced to a minimum. If the protection circuit operates, switch off and check R164 and R170.
4. Check that, at the nominal mains voltage for the transformer tap in use, the reading between the collector of TR165 (heat sink) and ground, is not less than +44V under load as in Step 3 above.

### 5.6 SETTING UP THE POWER AMPLIFIER

(i) Quiescent Current of Output Stage.

1. Set the Level control to zero and remove the loading from the instrument. Switch out the attenuator.
2. Switch off and disconnect the link between the collector of TR106 and ground (Fig. 4) The link is at the bottom rear right corner of the instrument, near a large electrolytic. Replace the link by a d.c.milli-ammeter (-ve to ground) and solder a capacitor of value 0.5 to 1 μ across the link pins. A.O.T. resistor, R119, is selected to give a quiescent current in the output pair, of 18 ± 2mA, as shown on the meter. (Wait 1 minute for current to stabilise.)
3. Switch off and restore circuit link.

Note: If Step 2 above proves impossible, check the voltage across the A.O.T. resistor. This should be approximately 1.2V. This checks that D103 and D104 are operative. Check next the output transistors on the heat sink, TR105 and TR106. Finally check R121, R122 and TR104. Also check TR107, R124, R125, R126, and D105.

(ii) Check the output d.c. devel between ground and the +ve end of C114 (See Fig. 4). It should be within 1 volt of *half* the supply rail. If not, check R102 R104, R108, R120 and C106 for leakage.

### 5.7 SETTING UP SQUARER

(i) Connect the oscilloscope to Square Output, 1V/div., 0.1ms/div.

(ii) Select Range 1-10kHz and a frequency of 1kHz, so that 1 cycle (square) occupies exactly 10 oscilloscope divisions.

(iii) Trim R136 for mark/space ratio of unity.

(iv) Change the polarity of trigger on the oscilloscope and retrim, if necessary, so that the transition of the square wave occurs at the same point on the oscilloscope, near the 0.5ms centre. This should eleminate possible oscilloscope nonlinearity.

(v) Verify that amplitude is within specification. If excessive, suitably shunt front panel control R142 (1kΩ ) by A.O.T. resistor, R143 across the pins at the output of the squarer projecting from the track side of the PCB. Should the output be less than specified, check D131 (24V Zener), R142, R132, R133 and R134, in this order.

(vi) Confirm that rise and fall times are within specification. If not, check R135 and C133.

### 5.8 DISTORTION (See Fig. 3)

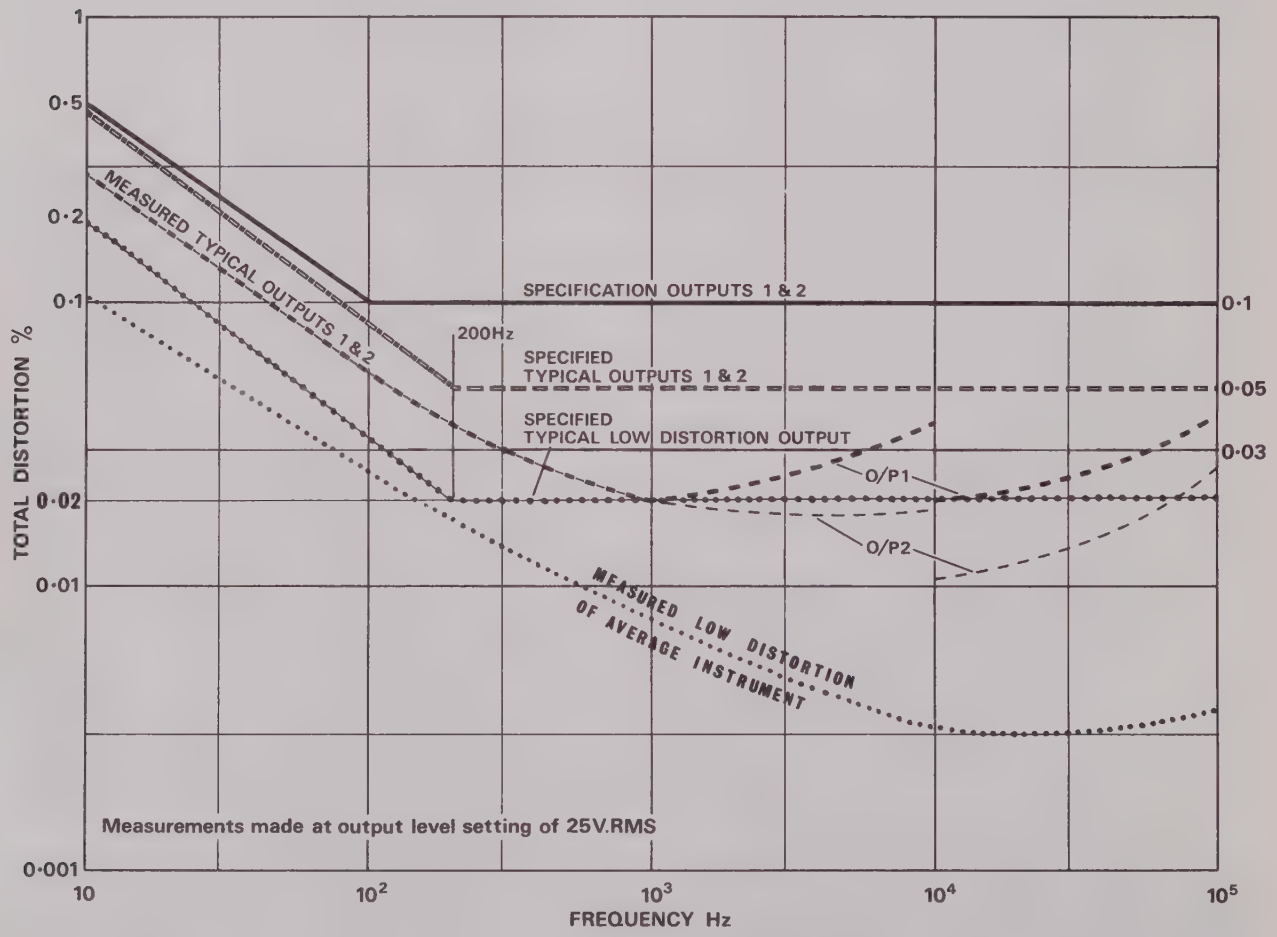
(i) If the preceding adjustments have been carried out correctly, distortion should be well within specification Apart from obviously faulty circuitry, the following is a short check list of the more likely causes of excessive distortion, if the instrument is functioning in other respects. If available, a Distortion Factor Meter is invaluable in tracking down distortion, particularly if possessing an output giving residual component frequencies after cancellation of the fundamental.

1. Change of component parameters could cause short burst of high frequency oscillation at some specific point of the signal cycle, as seen on an oscilloscope, particularly immediately after switching on when oscillator amplitude is still unstablised. When the J3 with this form of distortion is used as a signal source, it will generally result in 'noisy' or flickering measurements.
2. Cross-over distortion in the power output stage, generally due to failure or error in the bias components (see section 5.7 i) or damaged output transistors.
3. Supply hum or signal ripple across the 37V rail, caused by power supply failure or damaged electrolytic, C115. At full loading, the total supply + signal ripple across C115, should not exceed 40-50 mV p-p.
4. Square Wave break-through, caused by failure of TR131 or TR134.
5. If the distortion output gives predominantly 3rd harmonic at 10kHz, higher than the value specified, with corresponding increases of distortion at lower frequencies, suspect a faulty stabilising Thermistor in the oscillator.

(ii) Any failure or error in the feedback paths (including Switching) in the P.A., or wrongly set protection and limiting circuits in the P.S., can cause large distortion, increasing with output level.

(iii) If the distortion increases with output level beyond the specified limits then the fault is with the P.A. If the fault is in the oscillator, then distortion is sensibly independent of level at all outputs.

Fig. 3 Graph of Distortion and Frequency



## ABBREVIATIONS USED FOR COMPONENT DESCRIPTIONS

| | | | | |
|---|---|---|---|---|
| **RESISTORS** | | | | |
| CC | Carbon Composition | ½W | 10% | unless otherwise stated |
| CF | Carbon Film | 1/8W | 5% | unless otherwise stated |
| MO | Metal Oxide | ½W | 2% | unless otherwise stated |
| MF | Metal Film | ¼W | 1% | unless otherwise stated |
| WW | Wire Wound | 6W | 5% | unless otherwise stated |
| CP | Control Potentiometer | | 20% | unless otherwise stated |
| PCP | Preset Potentiometer MPD PC | | 20% | unless otherwise stated |
| **CAPACITORS** | | | | |
| CE(1) | Ceramic | | + 80%<br>− 25% | |
| CE(2) | Ceramic | 500V | ± 10% | unless otherwise stated |
| SM | Silver Mica | | | |
| PF | Plastic Film | | ± 10% | unless otherwise stated |
| PS | Polystyrene | | | |
| PE | Polyester | | ± 10% | unless otherwise stated |
| PC | Polycarbonate | | | |
| E | Electrolytic (aluminium) | | + 50%<br>− 10% | |
| T | Tantalum | | + 50%<br>− 10% | |

| Circuit Ref. | Value | Description | Tolerance % | | | Part No. |
|---|---|---|---|---|---|---|
| RESISTORS | | | | | | |
| R1 | 30M | MF | ±1 | | | 32772 |
| R2 | 3M | MF | ±0.5 | | | 32773 |
| R3 | 300K | MF | ±0.5 | | | 32774 |
| R4 | 30K | MF | ±0.5 | | | 32775 |
| R5 | 30M | MF | ±1 | | | 32772 |
| R6 | 3M | MF | ±0.5 | | | 32773 |
| R7 | 300K | MF | ±0.5 | | | 32774 |
| R8 | 30K | MF | ±0.5 | | | 32775 |
| R9 | 270 | CF | ±5 | 1/8W | | 28720 |
| R10 | 5K | Cp | | | | A4/32606 |
| R11 | 47K | CF | ±5 | 1/8W | | 21815 |
| R21 | 100K | CF | ±5 | 1/8W | | 21819 |
| R22 | 25K | Cp | | | | 29602 |
| R23 | 47K | CF | ±5 | 1/8W | | 21815 |
| R24 | 1K | CF | ±5 | 1/8W | | 21799 |
| R25 | 15K | CF | ±5 | 1/8W | | 28727 |
| R26 | 5K6 | CF | ±5 | 1/8W | | 21806 |
| R27 | 560 | CF | ±5 | 1/8W | | 21798 |
| R28 | 1K8 | CF | ±5 | 1/8W | | 28725 |
| R29 | 750 | MO | ±2 | | | 28790 |
| R30 | 390 | MO | ±2 | | | 26740 |
| R31 | 2K2 | CF | ±5 | 1/8W | | 21802 |
| R32 | 1K5 | MO | ±2 | | | 26733 |
| R33 | 1K | MO | ±2 | | A.O.T. | 27346 |
| R34 | 1K | CP | | | | 32523 |
| R35 | 12K | CF | ±5 | 1/8W | | 21810 |
| R36 | 330 | CF | ±5 | 1/8W | | 28721 |
| R37 | 180 | CF | ±5 | 1/8W | | 21795 |
| R38 | 1K8 | CF | ±5 | 1/8W | | 28725 |
| R39 | 680 | CF | ±5 | 1/8W | | 28723 |
| R40 | 1K | CF | ±5 | 1/8W | | 21799 |
| R41 | 33K | CF | ±5 | 1/8W | | 21814 |
| R42 | 100 | CF | ±5 | 1/8W | | 21794 |
| R43 | 2K7 | CF | ±5 | 1/8W | | 28726 |
| R44 | | Thermistor R15 | | | SELECTED | 32421 |
| R45 | 330 | CF | ±5 | 1/8W | | 28721 |
| R46 | 3K9 | CF | ±5 | 1/8W | | 21804 |
| R101 | 4K7 | CF | ±5 | 1/8W | | 21805 |
| R102 | 33K | CF | ±5 | 1/8W | | 21814 |
| R103 | 68 | CF | ±5 | 1/8W | | 28716 |
| R104 | 100K | CF | ±5 | 1/8W | | 21819 |
| R105 | 6K8 | CF | ±5 | 1/8W | | 21807 |
| R106 | 3K3 | CF | ±5 | 1/8W | | 21803 |
| R107 | 82 | XX | ±5 | 1/8W | | 28717 |
| R108 | 16K | MO | ±2 | 1/8W | | 28805 |
| R109 | 820 | CF | ±5 | | | 28724 |
| R110 | 330 | MO | ±2 | | | 26741 |
| R111 | 2K7 | MO | ±2 | 1/8W | | 26728 |
| R112 | 8K2 | CF | ±5 | 1/8W | | 21808 |
| R113 | 68 | CF | ±5 | 1/8W | | 28716 |
| R114 | 330 | CF | ±5 | 1/8W | | 28721 |
| R115 | 1K | CF | ±5 | 1/8W | | 21799 |
| R116 | 270 | CF | ±5 | 1/8W | | 28720 |

| Circuit Ref. | Value | Description | Tolerance % | | | Part No. |
|---|---|---|---|---|---|---|
| RESISTORS (Con't) | | | | | | |
| R117 | 120 | CF | ±5 | 1/8W | | 28718 |
| R118 | 56 | CF | ±5 | | | 28715 |
| R119 | | MO | ±2 | | A.O.T. | |
| R120 | 16K | MO | ±2 | | | 28805 |
| R121 | 1 | WW | | | | 34200 |
| R122 | 1 | WW | | 1/8W | | 34200 |
| R123 | 330 | CF | ±5 | | | 28721 |
| R124 | 1 | WW | | 1/8W | | 34200 |
| R125 | 22 | CF | ±5 | 1/8W | | 28710 |
| R126 | 1K | CF | ±5 | | | 21799 |
| R127 | 470 | CF | ±5 | 1/8W | | 21797 |
| R128 | 220 | CF | ±5 | 1/2W | | 18524 |
| R131 | 12K | CF | ±5 | 1/8W | | 21810 |
| R132 | 15K | CF | ±5 | 1/8W | | 28727 |
| R133 | 8K2 | CF | ±5 | 1/8W | | 21808 |
| R134 | 2K7 | CF | ±5 | 1/8W | A.O.T. | 28726 |
| R135 | 120 | CF | ±5 | 1/8W | | 28718 |
| R136 | 2K5 | CP | | | | 28969 |
| R137 | 15K | CF | ±5 | 1/8W | | 28727 |
| R138 | 8K2 | CF | ±5 | 1/8W | | 21808 |
| R139 | 470 | CF | ±5 | 1/8W | | 21797 |
| R140 | 2K2 | CF | ±5 | 1/8W | | 21802 |
| R141 | 12K | CF | ±5 | 1/8W | | 21810 |
| R142 | 1K | CP | | | | A4/32607 |
| R143 | | CF | ±5 | 1/8W | A.O.T. | |
| R144 | 100 | CF | ±5 | 1/8W | | 21794 |
| R151 | 10K | CF | ±5 | 1/8W | | 21809 |
| R152 | 10K | CF | ±5 | 1/8W | | 21809 |
| R153 | 2K5 | CP | | | | 28969 |
| R154 | 1K5 | CF | ±5 | 1/8W | | 21801 |
| R161 | 12K | CF | ±5 | 1/8W | | 21810 |
| R162 | 5K | CP | | | | 28970 |
| R163 | 22K | CF | ±5 | 1/8W | | 21812 |
| R164 | 2R2 | CP | | | | 34201 |
| R165 | 5K | CP | | | | 28970 |
| R166 | 22K | CF | ±5 | 1/8W | | 21812 |
| R167 | 22K | CF | ±5 | 1/8W | | 21812 |
| R168 | 6K8 | CF | ±5 | 1/8W | | 21807 |
| R169 | 68 | CF | ±5 | 1/8W | | 28716 |
| R170 | 1 | WW | | | | 34200 |
| R171 | 470 | CF | ± | 1/8W | | 21797 |
| R201 | 1480 | MF | ±1 | | | 32776 |
| R202 | 15K | MF | ±1 | | | 32777 |
| R203 | 1480 | MF | ±1 | | | 32776 |
| R204 | 15K | MF | ±1 | | | 32777 |
| R205 | 367 | MF | ±1 | | | 32778 |
| R206 | 306 | MF | ±1 | | | 32779 |
| R207 | 367 | MF | ±1 | | | 32778 |
| R208 | 306 | MF | ±1 | | | 32779 |
| R209 | 367 | MF | ±1 | | | 32778 |
| R210 | 306 | MF | ±1 | | | 32779 |
| R211 | 367 | MF | ±1 | | | 32778 |
| R212 | 306 | MF | ±1 | | | 32779 |

| Circuit Ref. | Value | Description | Tolerance % | | | Part No. |
|---|---|---|---|---|---|---|
| RESISTORS (Con't) | | | | | | |
| R221 | OR68 | CF | ±5 | | | 31888 |
| R222 | 278 | MF | ±1 | | | 32826 |
| R223 | 278 | MF | ±1 | | | 32826 |
| R224 | 187 | MF | ±1 | | | 29471 |
| R225 | 187 | MF | ±1 | | | 29471 |
| CAPACITORS | | | | | | |
| C1 | 6/25pF | | | | | 23593 |
| C2 | 6/25pF | Trimmer | | | | 23593 |
| C3 | | Trimmer | | | | |
| C5 | 1.5pF | | | | A.O.T. | 813 |
| C7 | 518pF +518pF | | | | C7A + C7B | 33999 |
| C8 | 68µF | E | | 16V | | 32174 |
| C21 | 150µF | E | | 16V | | 32175 |
| C22 | .33µF | pF | | 160V | | 34222 |
| C23 | 68µF | E | | 6.3V | | 32162 |
| C24 | 68pF | CE(2) | ±10 | 500V | | 22374 |
| C25 | 1000µF | E | | 16V | | 32178 |
| C26 | 5.6pF | CE(1) | | 500V | | 22361 |
| C27 | 150µF | E | | 16V | | 32175 |
| C28 | 470µF | E | | 6.3V | | 32164 |
| C29 | .01µF | CE(1) | | 250V | | 22395 |
| C30 | 33pF | CE(2) | ±10 | 500V | | 22370 |
| C31 | 470µF | E | | 40V | | 32191 |
| C32 | 47µF | E | | 40V | | 32188 |
| C101 | .33µF | PF | | | | 34222 |
| C102 | 22µF | E | | 25V | | 32181 |
| C103 | 5.6pF | CE(2) | | 500V | | 22361 |
| C104 | 56pF | CE(2) | | 500V | | 22373 |
| C105 | 680pF | CE(2) | ±10 | 500V | | 22385 |
| C106 | 150µF | E | | 16V | | 32175 |
| C107 | 82pF | CE(2) | | 500V | | 22375 |
| C108 | 470µF | E | | 6.3V | | 32164 |
| C109 | .01µF | CE(1) | | 250V | | 22395 |
| C110 | 56pF | CE(2) | | 500V | | 22373 |
| C111 | 470µF | E | | 6.3V | | 32164 |
| C112 | 56pF | CE(2) | | 500V | | 22373 |
| C113 | 5.6pF | CE(2) | | 500V | | 22361 |
| C114 | 330µF | E | | 16V | | 33998 |
| C115 | 2200µF | E | | 40V | | 31844 |
| C116 | 2200µF | E | | 25V | | 32520 |
| C131 | .1µF | CE(1) | | 30V | | 19647 |
| C132 | 22µF | E | | 25V | | 32181 |
| C133 | 33µF | E | | 500V | | 22370 |
| C134 | 47µF | E | | 25V | | 32182 |
| C151 | 47µF | E | | 10V | | 32167 |
| C161 | 33µF | E | | 16V | | 32173 |
| C162 | 47µF | E | | 25V | | 32182 |
| C163 | 47µF | E | | 63V | | 32199 |

| Circuit Ref. | Value | Description | Tolerance % | | Part No. |
|---|---|---|---|---|---|
| CAPACITORS (Con't) | | | | | |
| C164 | 2200pF | CE(2) | ±10 | 500V | 22389 |
| C165 | 47µF | E | | 40V | 32188 |
| C166 | 1000µF | E | | 63V | 32521 |
| C167 | .01µF | | +40 | | |
| | | CE(1) | -20 | 250V | 22395 |
| TRANSISTORS | | | | | |
| TR1 | | 2N3904 | | | 24146 |
| TR2 | | AE15 | | | A32067 |
| TR3 | | 2N3904 | | | 24146 |
| TR4 | | 2N3906 | | | 21533 |
| TR5 | | 2N3906 | | | 21533 |
| TR6 | | 2N3906 | | | 21533 |
| TR7 | | BC107 | | | 26790 |
| TR101 | | 2N3904 | | | 24146 |
| TR102 | | 2N3904 | | | 24146 |
| TR103 | | 2N3906 | | | 21533 |
| TR104 | | BCY70 | | | 23354 |
| TR105 | | MC140 | | | 32527 |
| TR106 | | MC150 | | | 32526 |
| TR107 | | 2N3906 | | | 21533 |
| TR131 | | BC108B | | | 26110 |
| TR132 | | 2N3906 | | | 21533 |
| TR133 | | 2N3906 | | | 21533 |
| TR134 | | 2N3904 | | | 24146 |
| TR161 | | 2N3904 | | | 24146 |
| TR162 | | 2N3904 | | | 24146 |
| TR163 | | BC108B | | | 26110 |
| TR164 | | BC107 | | | 26790 |
| TR165 | | 2N5296 | | | 28630 |
| DIODES | | | | | |
| D1 | 5V6 | | | | 4109 |
| D2 | 5V6 | | | | 4109 |
| D3 | | 1N4148 | | | 23802 |
| D4 | | 1N4148 | | | 23802 |
| D101 | 5V6 | | | | 4109 |
| D102 | | 1N4148 | | | 23802 |
| D103 | | 1N4003 | | | 32771 |
| D104 | | 1N4003 | | | 32771 |
| D105 | | 1N4148 | | | 23802 |
| D131 | 24V | | | | 22175 |
| D151 | | AAZ13 | | | 4472 |
| D152 | | AAZ13 | | | 4472 |
| D153 | | AAZ13 | | | 4472 |
| D154 | | AAZ13 | | | 4472 |

| Circuit Ref. | Value | Description | Tolerance % | | Part No. |
|---|---|---|---|---|---|
| MISCELLANEOUS | | | | | |
| L1 | | Choke | | | A4/32781 |
| BR161 | | W02 | | | 19725 |
| T1 | | Transformer | | L F.O/P | A1/32590 |
| T2 | | Transformer | | H.F.O/P | A1/32591 |
| T3 | | Transformer | | Supply | A1/32589 |
| FS1 | 250mA | Fuse | | SLO-BLO | 1898 |
| N1 | | Neon | | | 31870 |
| S1 | | Switch(Range) | | | 34466 |
| S2 | | Switch(P.B.) | | | 32604 |
| S3 | | Switch(Rocker) | | | 32612 |
| ME1 | | Sifam Type 23 | | | A3/32600 |
| SKA | | Terminal Guest Type TP2/4mm (Red) | | | 30137 |
| SKB | | Terminal Guest Type TP2/4mm (Black) | | | 30138 |
| SKC | | Terminal Guest Type TP2/4mm (Red) | | | 30137 |
| SKD | | Terminal Guest Type TP2/4mm (Red) | | | 30137 |
| SKE | | Terminal Guest Type TP2/4mm (Green) | | | 32735 |
| SKF | | Terminal Guest Type TP2/4mm (Red) | | | 30137 |
| SKG | | Terminal Guest Type TP2/4mm (Red) | | | 23635 |
| SKH | | Terminal Guest Type TP2/4mm (Black) | | | 23636 |

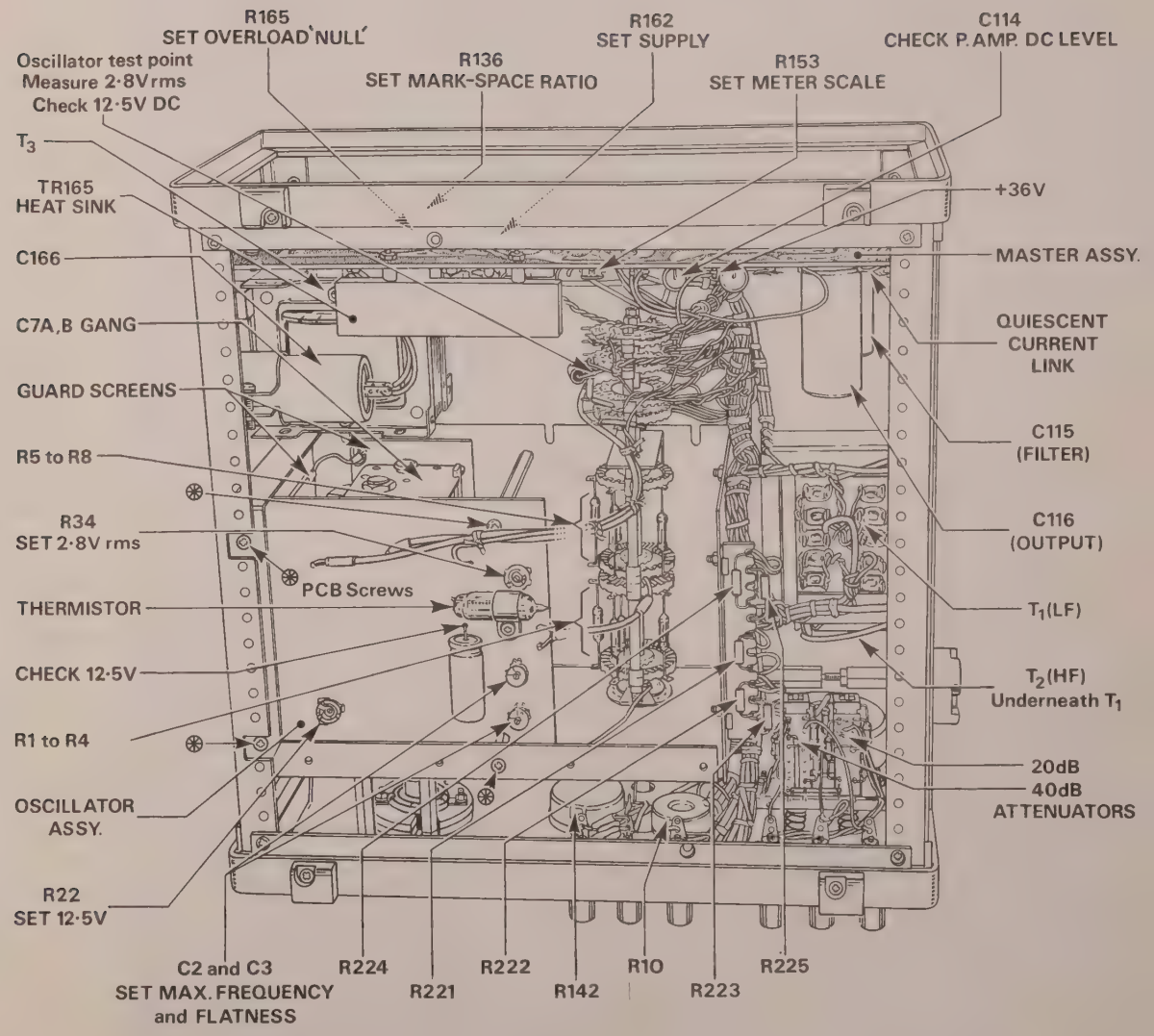



Fig. 4 Component Location Diagram

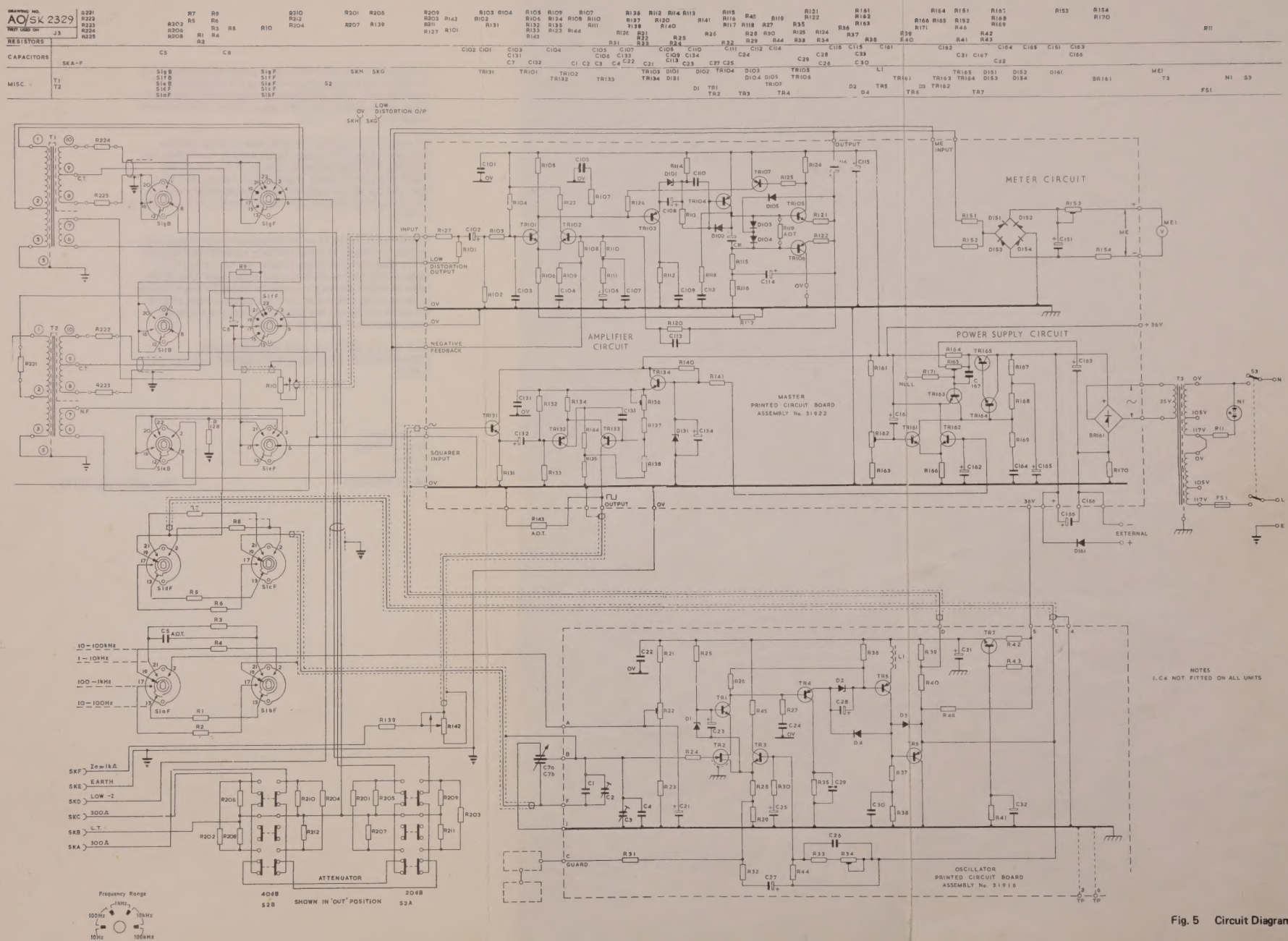



Fig. 5 Circuit Diagram

This instrument is guaranteed for a period of one year from its delivery to the purchaser, covering the replacement of defective parts other than tubes, semiconductors and fuses. Tubes and semiconductors are subject to the manufacturers' guarantee.

We maintain comprehensive after sales facilities and the instrument can, if necessary, be returned to our factory for servicing. The type and serial number of the instrument should always be quoted, together with full details of any fault and the service required. The Service Department can also provide maintenance and repair information by telephone or letter.

Equipment returned to us for servicing must be adequately packed, preferably in the special box supplied, and shipped with transportation charges prepaid. We can accept no responsiblity for instruments arriving damaged. Should the cause of failure during the guarantee period be due to misuse or abuse of the instrument, or if the guarantee has expired the repair will be put in hand without delay and charged unless other instructions are received.

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